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SUPPORT RACK FOR VIBRATORY TESTING OF PRINTED CIRCUIT BOARDS

Field of the Invention

- 5 The invention relates generally to the field of support racks and, more particularly, to racks used to support printed circuit boards.

Background of the Invention

- 10 Few products are sold by their manufacturer without some type of testing being conducted. Such testing may be as simple as manually ascertaining whether certain parts are securely affixed -- or as complex as "stress testing." In stress testing (or "stress screening" as it is sometimes called), products exhibiting "infant mortality" fail outright during the test. Or as the result of such testing, a product may evidence the likelihood of early failure in the operating environment. And some aspects of stress
15 testing involve testing to destruction while measuring certain performance parameters and/or the elapsed time to failure.

- Stress testing is most frequently employed with respect to products used in demanding applications and for which exceptionally-high reliability is required. Examples include products used on ground-travelling military equipment and products
20 (e.g., electronic and electromechanical products) used in aircraft of essentially all types.

- Stress testing may be carried out in any of several different ways. One type of test regimen involves imposing rapid, extreme changes in temperature upon the product. As an example, a test chamber may be used to change the temperature of a
25 product at the rate of, e.g., 10 degrees C. (about 18 degrees F.) per minute. Exemplary environmental test chambers used for such test regimens are disclosed in U.S. Patent Nos. 5,072,177 (Liken et al.) and 5,191,282 (Liken et al.).

- Another type of stress testing involves testing a product by subjecting it to vibrations of the type which might be encountered in actual product use. Vibration
30 stresses on the order of ten times the force of gravity ("10 Gs") are not uncommon. Vibration testing is carried out by mounting the product to be tested upon some sort of

platform or table and then vibrating the table using a rotating eccentric or a linear vibrator. An exemplary vibrator-driven table apparatus used for such stress testing is disclosed in U.S. Patent No. 5,804,732 (Wetzel et al.).

Yet another type of stress testing is known as highly accelerated stress testing (HAST) and involves subjecting products, e.g., printed circuit boards (PCBs), to vibrational stress forces as high as 50Gs. Such forces are applied randomly to the product along and in six axes of motion (as the industry describes it), i.e., along each of the linear X, Y and Z axes and in rotational axes about such linear axes. Such vibrational testing may be carried out alone or while the PCBs are also subjected to extreme thermal stress involving temperature changes at the rate of 60 degrees C. (about 110 degrees F.) per minute. In the latter instance, the vibrator table with PCBs supported thereon is placed inside a chamber. Such chamber is configured with heating and refrigeration capabilities to permit extreme and rapid temperature changes inside the chamber simultaneously with vibration testing. A leading manufacturer of environmental and vibrational testing equipment is Thermotron Industries of Holland, Michigan.

When configuring PCB support racks for such tests, there are number of design considerations. Among them are circulation of air around the PCBs (to facilitate the aforescribed rapid changes in the temperature of the boards) and transfer of vibrational forces to the PCBs.

While prior art PCB support racks (such as, e.g., the carrier disclosed in U.S. Patent No. 5,268,637 (Liken et al.) have been generally satisfactory for their intended purposes, they are not adequate for vibrational testing, especially the HAST regimen described above. A reason relates to transfer of vibrational forces from the vibrator table to the PCBs. The carrier shown in the aforementioned Liken et al. '637 patent contemplates slide-in and plug-in board mounting. Such mounting does not adequately transfer vibrational forces.

An improved support rack for vibration and thermal testing of printed circuit boards would be a distinct advance in the art.

Objects of the Invention

It is an object of the invention to provide a circuit board rack overcoming some of the problems and shortcomings of earlier racks.

Another object of the invention is to provide a circuit board support rack which
5 may be used for highly accelerated stress testing.

Yet another object of the invention is to provide a circuit board support rack with rigidity and board clamping capability selected to cause transmission of the energy of vibration from a vibratory table to the boards undergoing test.

Another object of the invention is to provide a circuit board support rack which
10 accommodates a range of sizes of printed circuit boards.

Still another object of the invention is to provide a circuit board support rack configured to permit ample air flow around and across the boards for thermal stress testing. How these and other objects are accomplished will become apparent from the following descriptions and from the drawings.

Summary of the Invention

The invention involves a rack for supporting printed circuit boards during vibratory (and, optionally, thermal) testing which, often, involves testing the boards to destruction. The purpose of such testing is to ascertain how sturdily the boards are
20 designed and manufactured and how much severe service they might withstand before failure.

The new circuit board support rack comprises a frame which is generally orthogonal in configuration and includes a pair of upright, longitudinally-spaced end panels having a pair of laterally-spaced lower rails extending therebetween. A board
25 engagement platform is fixed with respect to the frame and is "framed" by the end panels and rails. Such platform includes plural edge engagement members extending laterally between the rails. Each such member has a linear engagement groove for receiving and securing the lower edge of a respective printed circuit board.

Spaced above the platform by some dimension and oriented generally parallel
30 thereto is a board retention member. The dimension by which such member is spaced from the engagement platform may be selected by a first adjustment mechanism. In a

specific embodiment, each end panel has two vertical rows of apertures. Such rows are spaced laterally from one another and the apertures defining a row are, preferably, spaced vertically from one another.

When the board retention member is located at the approximate desired
5 dimension above the engagement platform (i.e., desired in view of the edge-to-edge measurement of the boards to be supported), respective shoulder screws are inserted through corresponding apertures in each of the four vertical rows of apertures and threaded snugly into the retention member. The apertures and shoulder screws coact with the frame and the retention member and comprise the first adjustment mechanism.
10 Such mechanism permits adjusting, in small, predetermined increments, the dimension between the platform and the retention members. Assuming the end panels, rails, engagement platform and retention member are tightly and securely affixed to one another, the rack will transmit vibration from the vibratory table to the circuit boards under test.

15 The rack also includes at least one second adjustment mechanism (and preferably a plurality thereof) on the retention member. Each such second adjustment mechanism is mounted for movement toward and away from the engagement platform while the platform-to-retention member dimension is held substantially constant. In a specific, highly preferred embodiment, the rack has at least first and second pluralities
20 of second adjustment mechanisms. Most preferably, each plurality includes three laterally-spaced adjustment mechanisms.

Merely as an example, the first plurality of second adjustment mechanisms includes first, second and third adjustment mechanisms. Further, each of the latter mechanisms comprises a respective clamping screw (i.e., first, second and third
25 clamping screws), each having its own locating pin (i.e., first, second and third locating pins). When the first or lower and second or upper edges of a printed circuit board are inserted between, respectively, a particular edge engagement member and the second adjustment mechanism (or plurality of such mechanisms) immediately thereabove, the locating pins of the individual mechanisms are oriented so that the notches therein
30 engage the upper printed circuit board edge. The second adjustment mechanisms are tightened to securely hold the board for vibratory testing. When such mechanisms are

tightened, compressive force is exerted on the boards by the engagement platform and the retention member. Such force might be considered to be exerted substantially parallel to or substantially coincident with a planar surface of the printed circuit board.

From the foregoing and, particularly, from the drawings and the detailed
5 description which follows, certain dimensional relationships of a specific, preferred embodiment will be apparent. The first dimension, i.e., that dimension between the engagement platform and, say, the underside of the board retention member, may be selected in increments that are predetermined by the spacing between apertures of the first adjustment mechanism. It is fair to say that this configuration permits adjustment
10 that is somewhat "coarse."

It is to be understood that the locating pins protrude below the underside of the retention member. Thus, the locating pins (or at least an exemplary pin) is spaced from the engagement platform by a second dimension which is somewhat less than the first dimension. The aforescribed configuration of the second adjustment mechanism
15 permits the second dimension to be selected in a continuum rather than in discrete increments. One might say that such configuration permits "fine" adjustment to securely clamp each of the boards to undergo test.

To effect such testing, the frame (and, more specifically, each of the rails of such frame) include plural openings therealong. The spacing between such openings is
20 preferably selected to conform to the spacing of holes in the vibratory table. To secure the rack, boards and vibratory table to one another, bolts are extended through such openings and threaded into the holes in the table.

Further details of the invention are set forth in the following detailed description and in the drawings.
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Brief Description of the Drawings

FIGURE 1 is a perspective view of the new support rack shown in connection with a vibrator table.

FIGURE 2 is an elevation view of one of the end panels of the rack of
30 FIGURE 1 taken along the viewing axis VA2.

FIGURE 3 is a side elevation view of the rack of FIGURE 1 taken along the viewing axis VA3 and with the vibrator table omitted and two rack-mounted circuit boards included.

FIGURE 4 is an exploded view of an exemplary second adjustment mechanism. A portion of the board retention member is shown in dashed outline.

FIGURE 5 is an elevation view of three of the second adjustment mechanisms affixed to an exemplary clamping bar.

FIGURE 6 is a representation of six axes of motion (three linear and three rotational) which may be applied to circuit boards mounted in the rack.

FIGURE 7 is a perspective view of an environmental test chamber with which the rack might be used.

Detailed Descriptions of Preferred Embodiments

Referring first to FIGURES 1, 2 and 3, the inventive support rack 10 includes a frame 11 which is generally orthogonal and includes upright, generally planar first and second end panels 13, 15, respectively, which are parallel to and longitudinally-spaced from one another. Each panel 13, 15 has an air circulation window 17 formed in it. Extending between the panels 13, 15 and generally perpendicular thereto are elongate, laterally-spaced first and second rails 19, 21, respectively.

Each rail 19, 21 has a plurality of openings 23 therealong. Such openings 23 are preferably sized and spaced in view of the size and spacing of the openings 25 in the top of the vibrator table 27. In that way, the rack 10 can be readily bolted to the table 27. A board engagement platform 29 is rigidly fixed between the end panels 13, 15 and between the rails 19, 21 and has at least one (and preferably a plurality) of engagement members 31, each having a linear engagement groove 33 formed therein. As described in more detail below, circuit boards 35 to undergo test have their lower or first edges 37 received in respective grooves 33.

The rack 10 also includes a board retention member 39 which is generally parallel to the platform and is spaced above such platform by dimension D1. The member 39 has elongate, laterally-spaced first and second support bars 41, 43, respectively. The member 39 also includes plural clamping bars 45 such as bars 45a

Summary
and 45b. The bars 45 are elongate, extend laterally between and are rigidly affixed to the support bars 41, 43.

Referring particularly to FIGURES 1 and 2, the rack 10 includes a first adjustment mechanism 47 by which the dimension D1 may be selected in
5 predetermined increments. Such mechanism 47 includes first and second rows of apertures 49, 51, respectively, in the first end panel 13 and third and fourth rows of apertures 53, 55, respectively, in the second end panel 15. While each such row 47, 49, 51, 53 may have a single row component 57 of apertures, smaller adjustment increments are facilitated when each row 47, 49, 51, 53 includes a side-by-side pair of
10 such components 57 with particular apertures of one component, e.g., component 57a, being slightly vertically "staggered" from the corresponding apertures of the adjacent component 57b. Irrespective of whether rows or row components are used, the apertures 59 of a row component 57 are preferably arranged substantially vertically from one another.

15 Sub A27 The first adjustment mechanism 47 also includes a plurality of shoulder screws 61, four in the preferred embodiment. Each screw 61 extends through a respective aperture 59 in one of the four rows 47, 49, 51, 53, and threads into the retention member 39. Apertures 59 are preferably located and selected in such a way that in any vertical position of the retention member 39, such retention member 39 is parallel to
20 the engagement platform 29 when the rack 10 is assembled for use.

Referring to FIGURES 4 and 5, the rack 10 also includes at least one second adjustment mechanism 63 (and preferably first, second and third mechanisms 63a, 63b, 63c, respectively) laterally spaced from one another on each clamping bar 45 of the retention member 39. Certain parts of each such second adjustment mechanism 63 are
25 mounted for movement toward and away from the engagement platform 29 while the platform-to-retention member dimension D1 is held substantially constant.

Each of the second adjustment mechanisms 63 comprises a clamping screw 65 having its own locating pin 67. Each such pin 67 has a notch 69 formed therein. When the first or lower edge 37 and the second or upper edge 71 of a printed circuit
30 board 35 are inserted between, respectively, a particular edge engagement member 31 and the second adjustment mechanism 63 immediately thereabove, the locating pins 67

of the individual mechanisms 63 are to be oriented so that the pin notches 69 engage the printed circuit board upper edge 71. The second adjustment mechanisms 63 are tightened to securely hold the boards 35 for vibratory testing. When such mechanisms 63 are tightened, compressive force is exerted on the boards 35 by the engagement platform 29 and the retention member 39. As represented by the arrows 73, 75, such force might be considered to be exerted substantially parallel to or substantially coincident with a planar surface of the printed circuit board 35. (FIGURE 4 shows that each adjustment mechanism 63 has a clamping screw 65, a deck nut 77, a pair of vibration-proof washers 79 and a screw foot 81 which is press-fitted into the locating pin 67. The dashed outline 83 shows the location of a clamping bar 45 with respect to the components of the mechanism 63.)

Considering FIGURES 2 and 3, the dimension D1 is measured along a first axis 85 and each row of apertures (i.e., row 55) extends along a second axis 87 substantially parallel to the first axis 85. Each of the linear engagement grooves extends along a third axis 89 which is substantially perpendicular to the first axis 85. (It is to be appreciated that the dimension D1 could be measured anywhere along the engagement member 31 and between the panels 13, 15.)

It is to be understood that the locating pins 67 protrude below the underside of the retention member 39. Thus, the locating pins 67 (or at least an exemplary pin 67a) is spaced from the engagement platform 29 by a second dimension D2 which is somewhat less than the first dimension D1. The aforescribed configuration of the second adjustment mechanism 63 permits the second dimension D2 to be selected in a continuum rather than in discrete increments.

In use, an operator of the test equipment is able to load circuit boards 35 "off line," i.e., by using a rack 10 other than the rack 10 bolted to the vibrator table 27 as shown in FIGURE 1. Board loading is by slidably inserting the lower edge 37 of a board 35 into and along one of the grooves 33 in the platform 29, holding the board 35 vertically, aligning the notch(es) 69 of the corresponding adjustment mechanism(s) 63 with the upper edge 71 of the board 35 and tightening the mechanism(s) 63. While a rack 10 could be constructed to hold but a single board 35, more rapid testing will be facilitated if the rack 10 holds plural boards 35, e.g., twelve or so.

Assuming a rack 10 containing boards 35 is undergoing test during off line loading of another rack 10, the test rack 10 is removed at the conclusion of test by removing the bolts (not shown) from the openings 23, 25. The rack 10 which has been newly-loaded with boards 35 is bolted to the table 27 in place of the first rack 10.

5 Usually, the circuit boards 35 undergoing test are operated (or at least electrically monitored) during such test. Electrical connections to such boards 35 may be by edge connectors, for example.

10 The material selected for rack construction must be sufficiently hard and rigid to effectively transmit table vibration to the boards 35 undergoing test. Magnesium and aluminum are suitable; lead and plastic are not.

Referring also to FIGURE 6, the new rack 10 is suitable for testing printed circuit boards 35 in what is known in the industry as six axes (three linear and three rotational) of motion. Such axes include three linear axes 91, 93, 95, respectively, and three rotational axes 97, 99, 101, respectively.

15 FIGURE 7 shows a representative environmental test chamber 103 in which the rack 10 containing boards 35 is mounted. The vibrator table 27 (as well as the driving mechanism therefor) are in the chamber 103 and the rack 10 is bolted to the table 27 as described above. The ducts 105 are used to direct hot and cold air across the boards 35 during vibration testing.

20 In this specification, terms such as upper, lower, vertical, side-by-side and the like are used to facilitate understanding and are not intended to limit the scope of the invention. And while the principles of the invention have been shown and described in connection with preferred embodiments, it is to be understood that such embodiments are by way of example and are not limiting.

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